ON THE GENUS *BOTELLINA* (Carpenter), WITH A DESCRIPTION OF A NEW SPECIES.

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(Plate XX.)

INTRODUCTION.

In the year 1869 the late Professor H. P. Carpenter first described what was at that time considered the most interesting and largest known recent arenaceous *Rhizopod*, measuring 1 inch (25 mm.) in length, with the diameter of $\frac{1}{8}$ inch (3 mm.), judging from broken specimens, to which he gave the generic name *Botellina*, no mention being made of a specific name.

Since that time, however, a number of new arenaceous *Rhizopods* have been discovered fully $1\frac{1}{2}$ inches, or more; *i.e.*, *Syringammina fragillissima*,* from the Faröe Channel, in a depth of 555 fathoms; *Hyperammina palmiformis*,† also from the Faröe Channel, in 516 fathoms; *Reophax nodulosa*,‡ from the Antarctic and Pacific Oceans, in depths from 1,300 to 2,900 fathoms; *Pelosina variabilis*,§ and others.

In 1881 Dr. H. B. Brady redescribed the genus *Botellina* (from the same fragmentary specimens with which Professor H. P. Carpenter had made his description in 1869), and to which he gave the specific name *labyrinthica*,‖ reproduced and figured in the *Challenger* Reports, Foraminifera.¶ *Botellina labyrinthica*, Brady, was first obtained in some abundance at a single station (No. 51) on the third cruise of H.M.S. *Porcupine*, in 1869, at a point lying on the border-line, between the warm and cold areas of the Faröe Channel, at a depth of 440 fathoms, lat. 60° 6′ N., long. 8° 14′ W., bottom tempera-

* H. B. Brady, Proc. Roy. Soc., 1883, vol. xxxv., p. 155, pls. 2–3.
† F. G. Pearcey, Trans. Nat. Hist. Soc., Glasgow, vol. ii., pt. 2, new series, pl. 3, 1887–8.
‡ H. B. Brady, Chal. Reports Foraminifera, vol. ix., p. 294, pl. 31, figs. 1–9.
§ Ibid. pp. 235–236, pl. 26, figs. 7–9.
‖ Ibid., Quart. Journ. Micr. Sci., vol. xxi., new series, p. 48.
¶ Ibid. Chal. Reports, Foraminifera, vol. ix.

ture 42° F., and the surface water 51·6° F. It was again met with by the Naturalists of the *Knight Errant* and *Triton* Expeditions in 1880 and 1882, but always in a fragmentary condition in the same areas, at a depth of 516 fathoms in the warm area, and in 580 fathoms in the cold area, with a bottom temperature 46·5 and 31° F. respectively. It would thus appear to be more common in the cold area, where it was taken in the greatest abundance, strongly indicating that it favours a low temperature.

In 1886 Mr. Joseph Wright, F.G.S.,* again records *B. labyrinthica* as having been obtained in considerable abundance in a dredging taken about midway between Belfast Lough and Portpatrick, at a depth of 100 fathoms,† and again in September, 1902, from washings of dredged material from Rathlin Sound, Church Bay, in 17 to 24 fathoms, but he makes no mention of the temperature of the water. So far as I am aware, *B. labyrinthica* has not since been taken or recorded from any other locality.

Ten years later (in 1879), after its first discovery, I had the pleasure of examining some of the specimens of *B. labyrinthica* obtained by the *Porcupine* Expedition, which I considered at that time were merely fragments of an incomplete species, and mentioned the fact to the late Dr. H. B. Brady, who quite agreed with me. At that time he was preparing the *Challenger* Report; we also held similar views with regard to other arenaceous forms described and figured in that publication, viz., *Rhabdammina discreta*, *Hyperammina friabilis*, and others, as was proved by the discovery of a new and perfect species of *Hyperammina* (*H. palmiformis*), figured and described by me from the Faröe Channel.‡

In December, 1904, while occupied, under the direction of Sir John Murray, examining a series of marine deposits collected on board the Cape Government Zoological investigation vessel, ss. *Pieter Faure* (the late Captain Turbyne), off the N.E. and S.W. coasts of Africa, and in the vicinity of the Agulhas Bank, I observed several fragments of a large arenaceous Foraminifera, which I considered to be closely allied to Professor H. P. Carpenter's genus *Botellina*. These samples of deposit had been sent to Sir John Murray direct from the Cape of Good Hope, as they were obtained by dredge, or trawl, and placed in canvas or strong cotton-cloth bags, so that the general character of the samples as a whole

* J. Wright, Foraminifera from Rathlin Island, *Irish Naturalist*, vol. xi., pp. 211–213.

† Ibid., second dredging cruise of the ss. *Protector*. Belfast Nat. Field Club, 1886.

‡ F. G. Pearcey, on the Foraminifera of the Faröe Channel, Trans. Nat. Hist. Soc., Glasgow, new series, 1887–8, pp. 163–79, vol. ii., pt. 2, pl. 3.

could not at the time be made out. On closer examination, later, it was found that several of these samples were made up almost wholly of a beautiful arenaceous Foraminifera of large dimensions, with an erect robust test, and pinnate in form, measuring from $\frac{3}{4}$ inch to 2 inches or more in height, $\frac{3}{8}$ inch to $\frac{1}{4}$ inch in circumference, varying in colour from a brick-red to light and dark brown, or burnt-sienna, of which in previous samples I had examined I had obtained only small fragments. At two stations, Nos. 593 and 594, lat. 33° 50′ S., long. 25° 54′ 30″ E. in 26 fathoms, the samples from both of these stations were found to consist of a mass of this gigantic Rhizopod, sufficient to more than fill a half-gallon measure—enough, surely, to gladden the heart of the most ardent Rhizopodist.

Here, then, was sufficient material to work out the true character and position of the genus *Botellina*, of which hitherto fragments only had been discovered. I therefore decided to examine all the samples carefully with that purpose in view. The results of my study are depicted in the following pages.

Notwithstanding the large amount of material on hand, there were still serious doubts as to whether all or any of the specimens were really perfect.

In the great number afterwards examined, I found that the basal portion of each individual specimen (with three exceptions) showed a true and more or less clean fracture (see figs. 1, *a–b*, pl. 1), as if they had been broken sharply off from a basal attachment, showing clearly that they must have been, when living in their natural condition, attached to some foreign body on the sea-floor, or had possessed a large primordial chamber embedded in the deposit to support such a large test; although diligent search was made nothing of the kind was found, till a sample of deposit obtained off Cape Natal was examined, viz., Station No. 11,074, Cape Natal, N. $\frac{1}{2}$ W., distant $4\frac{1}{2}$ miles, at a depth of 55 fathoms. In this deposit, composed of a siliceous sand, containing a considerable percentage of shell and coral fragments, amongst which a number of the large *Botellina* were found, seven large oval, sublenticular, and subangular arenaceous chambers were obtained, showing a prominent elongation or tubular neck at one point, similar in composition, character, and colour to the large fractured, robust pinnate form previously discovered, which at once connected them with the incomplete arenaceous tests or *Botellina*, mentioned above, as taken in mass at Stations Nos. 593 and 594; indeed, with two or three of these chambers it was found possible, with scarce a doubt, to fit the fracture of the neck-like prolongations of these chambers to the fractures at the basal ends of the large pinnate branching

form, thus providing it with a primordial chamber (see Pl. XX., figs. 2–3). And although I have not found a complete or perfect specimen, viz., "the large pinnate test with a primordial chamber intact," there can be no doubt that these few large cells or chambers, taken in the same haul with the branching tests, of the same characteristic form and composition, their fractured tubular necks fitting as they do, in two or three instances, exactly the broken basal portions of the larger erect branching tests, are the primordial cells with which they were fixed on the sea-floor, and from which these beautiful erect pinnate structures were produced, as will be seen by the following detailed description, with figures showing fractured and restored specimens (Pl. XX., figs. 1, 2, and 3).

Family ASTRORHIZIDÆ.

Sub-Family RHABDAMMININÆ.

Genus BOTELLINA, Carpenter.

Botellina, Carpenter (1869). Butschli, Brady.

GENERIC CHARACTERS.

Typical Form.

(*Botellina pinnata*, Pearcey.)

Test free, arenaceous, erect, pinnate, rising from a primordial chamber, oval, subglobular, subangular, or compressed in form, with pseudopodial openings situated at the extremity of pinnate outgrowths; walls thick, of very firm consistence, subdivided into chambers which communicate freely into a main tubular chamber, running through the whole test, compactly cemented and generally smooth externally, in colour ferric brown of various shades. It is conspicuous amongst all other known Astrorhizidæ by its robust form and size.

Primitive Form.

(*Botellina labyrinthica*, Brady.)

Test arenaceous, cylindrical, straight or slightly curved, somewhat irregular in outline, one end rounded and more or less swollen (the natural condition of the other end not certainly known); walls of the test of firm consistence, rough, without external fine cement, subdivided irregularly by a labyrinth of sand-grains cemented

together at various angles forming rude chamberlets which open out into a main tube (or chamber), which runs through nearly the whole test.

Incomplete specimens only known.

DEFINITION OF NEW SPECIES.

Botellina pinnata, sp. nov.

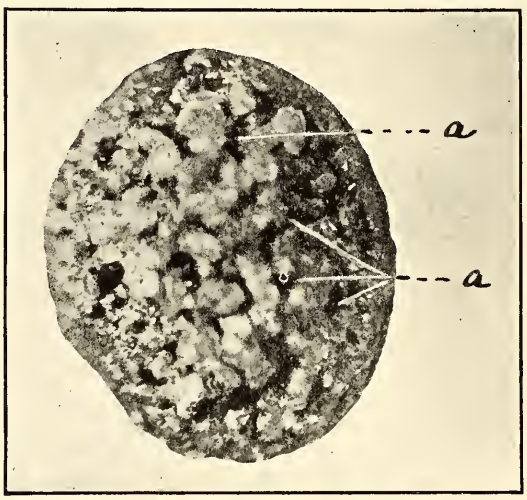
Test free, erect, arenaceous, comparatively smooth externally, tubular, in the form of a slightly compressed or rounded robust pinnate structure; the pinnate outgrowths rounded and slightly swollen, compressed or lobulated at their distal ends, with a series of pseudopodial apertures at the apex,—these are covered with a very fine, pale-coloured cement, from which (in the fresh state) numerous delicate transparent spicules project irregularly. Size, 1 to $2\frac{1}{2}$ inches (25 to 62 mm.) in height, with a diameter of $\frac{3}{16}$ to $\frac{3}{8}$ inch (3·5 to 6 mm.) rising from a basal or primordial more or less inflated chamber $\frac{3}{8}$ to about $\frac{1}{2}$ inch broad (9 to 12 mm.); oval, subglobular, subangular, or more or less compressed, from which arises a short cone-shaped neck before becoming divided into regular alternate pinnate outgrowths, which at times again divide into radiating branches or offshoots, but always retaining the pinnate character. Walls thick, of very firm consistence, finely cemented externally, and with minute chambers, which communicate into a main tubular passage running through the whole structure opening out freely, vestibular-like, into the pinnate outgrowths. Colour in various shades of red and brown, or ferric-brown.

The specimens on which the genus *Botellina* has been founded differ from all other known Astrorhizidæ, not only on account of its size, but in the general structure of its test, the walls of which are chambered, and therefore represents one of the highest types of structural development among the recent arenaceous Foraminifera.

In *Botellina pinnata* we have a well-defined method of building up the test; the main body of the test is composed of coarse materials. The walls are of firm consistence, $\frac{1}{16}$ to $\frac{3}{16}$ of an inch (35 to 10·5 mm.) in thickness, composed of siliceous grains, with a mean diameter of 0·5 mm., made up chiefly of *Quartz*, *Kircon*, and a sprinkling of *Glauconitic particles*, with an occasional *Garnet* or two, the whole incorporated by a siliceous and ferruginous cement. A thin layer on the exterior is more or less solid and imperforate, giving the whole structure a smooth and solid appearance. The

siliceous grains are so arranged in building up the wall that they form a network of minute chambers communicating freely with each other, and perforated with tubular-like passages opening out freely into a main central chamber, supplemented and strengthened at intervals by the extension of a portion of the walls into the interior; in the form of septa, constructed, like the remainder of the test, of cemented sand-grains (Pl. XX., figs. 8, 9).

These chambers, having free communication with each other, are generally quite filled with green sarcode, containing nuclear (?) corpuscles. Diameter of the central chamber variable (m. di. $\frac{1}{20}$ inch = 1·26 mm.), internal chitinous lining absent. The pseudopodial apertures are situated at the extreme or peripheral ends of the pinnate outgrowths (see woodcut), formed sometimes of three or



Front view of a peripheral end of one of the pinnate outgrowths of *Botellina pinnata*, sp. nov., after it has been treated with dilute hydrochloric acid. Magnified 12 diameters; *a*, *a*, pseudopodial apertures.

four transverse slits, or more generally of irregular spaces between the agglutinated sand-grains. These apertures are almost closed in with a light brown cement made up of carbonate of lime and ferruginous material, from which extend minute transparent spicules also formed of carbonate of lime, produced to all appearance by the organism itself as a protective agent. These portions are of a much paler colour than any other part of the test, due to a higher percentage of lime at these points than elsewhere, giving a bright and life-like effect to the whole structure.

On the test being laid open longitudinally, the main central chamber is seen to start from a large primordial cell, from whence a main passage runs through the whole structure, branching off into

vestibular-like passages to the pinnate outgrowths; the septa from the inner walls are exposed, as also the foramina, or tubular communications to the wall chambers which open out into it, shown in Pl. XX., figs. 8, 9, 10 and 11, *a*, *b*, *c*.

The same figures show the wall chambers, by means of microphotography, of the actual specimens, which are not accidental lacunæ, but in a measure regularly constructed; the sand-grains which form their walls are fixed to each other by a siliceous compound, and are arranged in a more or less orderly fashion, so as to form a labyrinth of minute chambers.

A transverse section across one of the pinnate outgrowths (Pl. XX., fig. 9) magnified twelve diameters shows the wall chambers more clearly. In this figure the thickness of the walls indicated; also the fine thin layer of siliceo-ferruginous cement, *d*, which contains about 2 per cent. of carbonate of lime, and forms the final outer coating of the walls.

The wall of the primordial cell is chambered in a similar manner to that of the remainder of the test (Pl. I., fig. 8*b*). It possesses one large, or from two to five small pseudopodial (?) openings (figs. 1–3 and 7*e*); oval, or slightly projecting outwards along the edge of its basal portion, which, when living, is most probably buried in the deposit on the sea-floor, and by which means it is enabled to support or anchor the large, erect, robust test.

The junction, or neck, connecting the distal portion of the test with the primordial chamber, being the weakest point of the whole structure, will doubtless account for so many imperfect specimens being taken by means of the trawl and dredge, minus the primordial chamber.

CONCLUDING REMARKS.

Dr. H. B. Brady, in his description of *Botellina labyrinthica*, gives its specific name evidently on account, as he states, of the interior of the tube being subdivided irregularly by a labyrinth of coarse sandy particles, except at the rounded terminal cavity (?) which forms an undivided chamber. And, later on, he states that the test has the appearance of a cylindrical tube of a somewhat irregular diameter, one end rather swollen and rounded, the other end always imperfect, apparently broken. At the broad end, the investment is thin and incomplete, and there are many orifices (*chambers*) * left between the sand-grains; and this fact, together with the broken condition of the specimens, gives rise to the supposition that when

* The italics are my own.

living the test is erect and sessile, growing attached or rooted by its narrow extremity to some fixed base, and that the interstitial orifice of the terminal chamber serves as the general aperture.

It would appear quite evident from the above that the late Dr. Brady was cognisant of the true character of this interesting rhizopod when in its perfect living condition, although no definite mention is made of the chamber walls; it must be borne in mind that he had but incomplete fragmentary specimens to deal with; the fact that he mentions the many orifices left between the sand-grains, and the interior of the tube (or central *chamber*)* in parts being subdivided, is, I take it, an admittance that he saw the primitive arrangement of chambers in the walls of the test.

Again, the late Dr. H. C. Carpenter (*loc. cit.*) states that the cavity of the tube is not divided into chambers by interposed septa, as in the genus *Reophax;* but it is continuous throughout, though traversed in every part of its length by irregular processes, which goes to prove its close affinity to the structure of the chambered walls of *Botellina pinnata.*

Neither Dr. Carpenter nor Dr. Brady mentions any special formation of chambers by the sand-grains in the building up of the walls of the test (except the irregular processes traversing the whole length of the tube (?)), from which it would be inferred that they both saw, at least in some of the fragments examined by them, a central continuous tube, or main chamber in direct communication with the interstices, cellular, or chambered wall structure. I have examined some of the actual specimens or fragments from which Messrs. Carpenter and Brady made their descriptions, and these show definite indications of chambers in the walls of the test, with inter-communications with the main chamber, resembling that of *B. pinnata*, but the fine material which forms the outer coating and gives the smooth and solid finish to the outer surface of the whole test of *Botellina pinnata* is altogether wanting in *B. labyrinthica;* still, I consider there is sufficient generic similarity to retain the new species under the genus *Botellina* founded by the late Dr. H. P. Carpenter, although on first acquaintance there is a strong desire to form a new genus, which, however, is lost sight of on structural examination of the tests of each species.

I wish here to thank my friend Mr. J. W. Tutcher, of Bristol, for the energetic manner in which he undertook the difficult task of producing by micro-photography figs. 8–11 on the Plate.

* The italics are my own.

List of Stations, with Localities, &c., from which *Botellina pinnata* have been obtained.

Number of Station.	Latitude.	Longitude.	Depth in Fathoms.	General Remarks.
547 and 548	33° 54′ 13″ S.	25° 53′ 30″ E.		*B. pinnata*, moderately common.
580	34° 1′ 30″ S.	25° 45′ 00″ E.		Two large specimens and fragments.
593 and 594	33° 50′ 00″ S.	25° 54′ 30″ E.		*B. pinnata*, in mass. These two samples fully filled a half-gallon measure of *B. pinnata* alone. In this sample were also obtained a few irregular perforated slabs of agglutinated shelly sand, overgrown with *Serpula*, *Polyzoa*, *Coral*, *Hydrozoa*, and *Foraminifera*, *Gasteropod*, and *Lamellibranch* shells, shell fragments, and siliceous sand.
781	33° 53′ 00″ S. (Off East about 17 of East	28° 12′ 00″ E. Beacon, miles E. London.)	45	Quite 2 lbs. in weight of *B. pinnata*, with a few *Gasteropods*, *Polyzoa*, and a mass of a large *Hydroid* (*Sestularia?*), sand and shell fragments. The *B. pinnata* taken in this haul are of a bright red colour.
805 and 806	33° 3′ 00″ S.	27° 57′ 00″ E.	32	A good many *B. pinnata*, brown and bright red in colour.
826 and 827	36° 6′ 45″ S.	27° 55′ 45″ E.	43	About 6 lbs. in weight of material, composed of sandy mud and shells, with hardened lumps of homogeneous mud. *B. pinnata* moderately common.
1,108 and 1,109	Bird Island Algoa	Passage, Bay.	10 to 16	A few specimens and fragments of *B. pinnata*, and a number of a smaller species, nov.
1,882	Cape St. N. by E., 73	Blaize, distant miles.	125	Several fragments.
10,778	Cape W. ¾ N., 12½	Natal, distant miles.	85	A few fragments of *B. pinnata*, with a number of specimens of a smaller species. Bottom deposit, a coarse sandy mud.
11,074	Cape Natal, 4½ miles	N. ½ W., distant.	55	This deposit, composed of a dead coarse shelly sand and coral fragments containing a number of ferric-brown phosphatic concretions, among which was found a good number of *B. pinnata*, and seven large primordial chambers belonging to them, together with many other large foraminifera, as *Polytrema rubra*, *Rupertia* sp. nov., *Astrorhiza* sp.? *Cristellaria*, &c.
10,834	Umhlote mouth, W. ½ W., 8½	River N. by distance miles.	40	A number of highly coloured *B. pinnata*, and some fragments of a smaller species, nov.
11,188	Mouth Umkomaas N.W. by distant	of the River, W. ½ W., 5¼ miles.		*B. pinnata*, in mass. Nearly a quart measure full, many with incrusting *Polyzoa*, with a great quantity of a large *Hydrozoa* (*Tubularia*? sp. ?), worm tubes, free *Polyzoa*, *Gasteropods*, and *Lamellibranchs*, with a quantity of shelly sand, shingle, and coral fragments.

EXPLANATION OF PLATE XX.

Botellina pinnata, sp. nov.

FIG.

1. *a*, Branching form, showing three offshoots from one primordial chamber; *b*, primordial chamber detached from the main test by the trawl when captured; slightly enlarged.

   The fractured parts, *c c*, shown in this figure were found to fit each other exactly; *e*, pseudopodial (?) apertures. Station 11,074; off Cape Natal; depth, 55 fathoms.

2–3. Typical forms of *B. pinnata*, with primordial chambers restored; the pseudopodial apertures are shown armed with delicate spicules; *e e*, pseudopodial (?) apertures. Station 11,074.

4. A somewhat compressed form, with double branching of pinnate outgrowths; primordial chamber broken off from distal portion of test; slightly enlarged. Station 593–594.

5. A double branching form minus the primordial chamber; slightly enlarged; this form of test was found comparatively common. Station 781; depth, 45 fathoms.

6. Specimen from Station 805–806, showing new offshoot from an old fracture of the test; natural size.

7. Detached primordial chamber before being ground down to show the interior and wall chambers; natural size; *e*, pseudopodial (?) apertures.

8. Detached primordial chamber (fig. 7), after a portion of one side has been ground away longitudinally; (microphoto) magnified 4 diameters; *a*, interior of main chamber; *b*, wall chambers; *c*, elongated neck showing tubular passage communicating to the upper portion of the main test and pinnate outgrowths; *d*, external covering of cement.

9. Micro-photograph of a transverse section across one of the pinnate outgrowths; magnified 12 diameters; *a*, main passage which forms the direct communication to the primordial chamber; *b b*, septa; *c*, wall chambers; *d*, thin layer of cement which forms the outer coating of the test.

10. Micro-photograph of a part longitudinal section of a portion of the test, magnified 4 diameters; *a*, main passage; *b*, tubular openings from the wall chambers into main passage; *c*, wall chambers exposed after external coating of cement has been removed.

11. Micro-photograph of a longitudinal section of two of the pinnate outgrowths showing numerous openings from wall chambers; *a a*, pseudopodial apertures. (See also woodcut, p. 190.)

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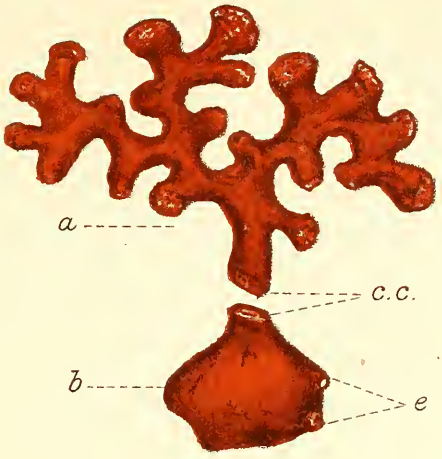

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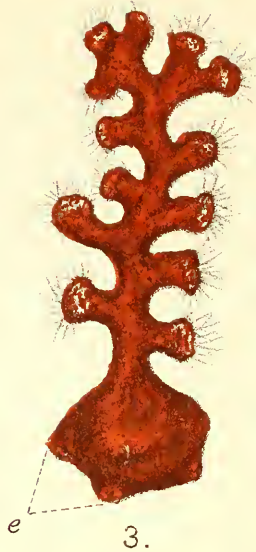

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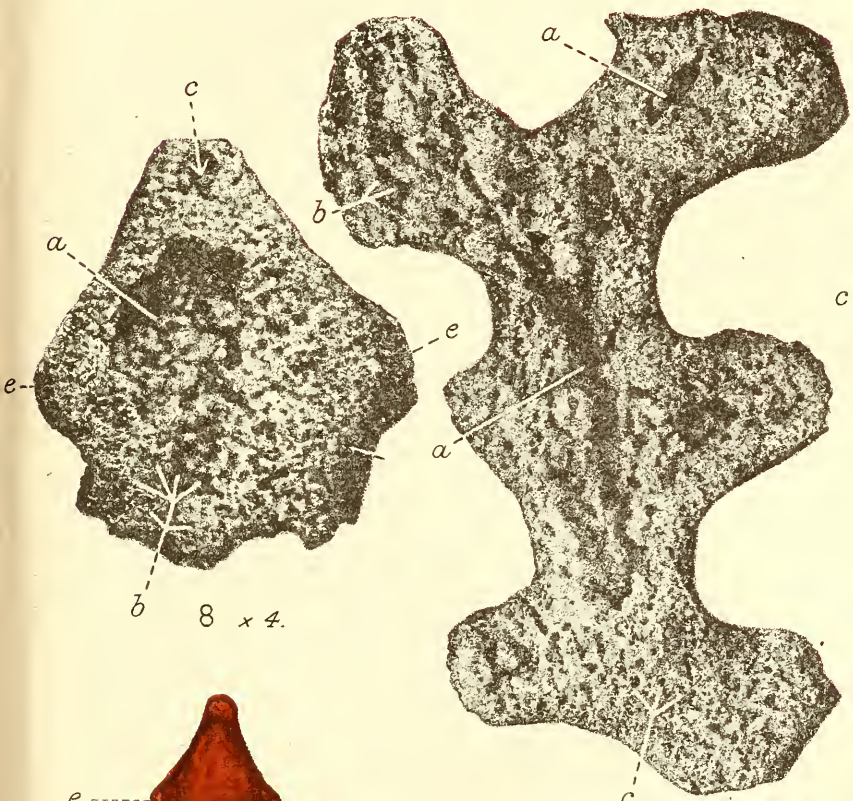

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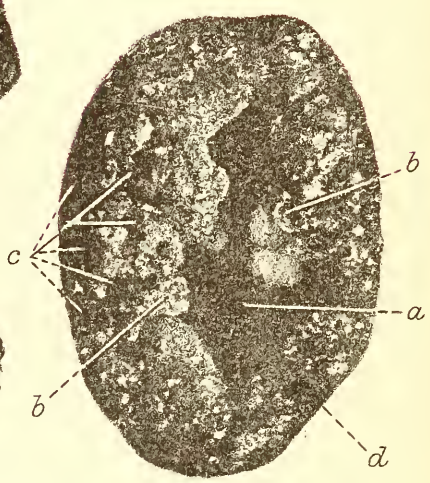

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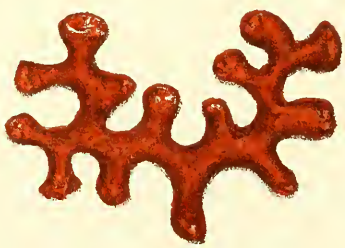

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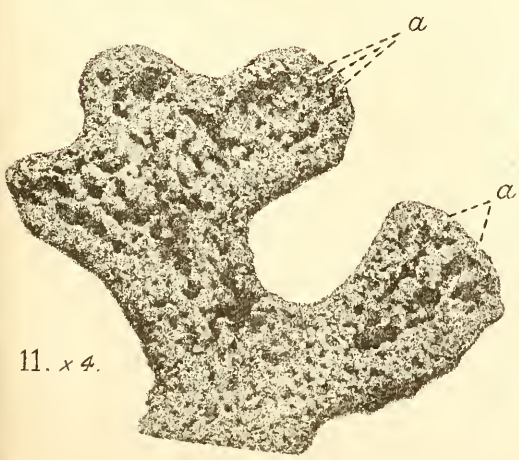

11. x 4.

6.

West, Newman lith.

BOTELLINA PINNATA *Sp. nov.*